DESIGN AND IMPLEMENTATION OF A RULE BASED SYSTEM FOR AMBULATORY NURSING DATA MANAGEMENT

James R Campbell MD, Robin Stoupa RN BSN, Judith J Warren RN PhD
University of Nebraska Medical Center, Omaha, NE

Abstract

In order to effectively organize the use of nursing time during clinic check-in, we designed a forward chaining rule based program for nursing history taking, problem tracking, and documentation. The program consists of a medical logic module trigger engine which identifies relevant rules for nursing history, an interactive question manager for nursing history taking, and a rule generation shell implemented within a specially designed Medical Query Language (MQL®) schema. At clinic check-in, the engine refreshes the rule set for the patient from interaction with the computerized medical record. The interaction driver assists the nurse with tracking of elapsed time, and allows him/her to pursue questions, record data, and create or complete nursing interventions. Nursing question sets and interventions are maintained longitudinally to assure continuity of care. Nursing problems are created on the problem list within the computerized record as the rule system identifies their existence.

Introduction

Primary care in the ambulatory setting is characterized by longitudinal patient involvement, brief patient encounters, varied training backgrounds for the staff and rationing of patient contact time. Care plans are orchestrated over weeks, and not necessarily accomplished within one, or even a few encounters. The nursing role in this setting is largely unstudied and difficult to describe, in part for these reasons. Yet the appropriate utilization of nursing services is critical to effective ambulatory care. The nurse is the greatest single resource of the clinic, and nursing salaries are the largest budget item in most ambulatory settings. Hence, effective use of nursing time is paramount.

The nurse's tasks and goals may be better defined in the setting where one nurse is assigned to a single physician, but this is rare in multispecialty clinics. The frequent use of clinic technicians or nurse extenders may further compromise the provision of nursing care. Nursing problem identification, documentation, and follow-up of care plans may be sacrificed in an effort to meet budgetary restraints.

However, the function of expert systems in other care settings and discussion by other developers[2,5,7,8] suggests that nursing care plans can be modelled and organized. We hypothesized that this was also true for the ambulatory nursing role.

In this paper we describe the steps we have taken to organize ambulatory nursing goals for hypertension into a forward chaining, rule based system for nursing history and problem solving. We discuss the elements of design particular to implementation of this system in a busy ambulatory clinic, and the preliminary response of the nursing staff to this implementation.

Description/methods

The Department of Internal Medicine at the University of Nebraska Medical Center has employed computerized ambulatory medical records in its outpatient clinic since 1983. An enhanced problem oriented version of the Computer Stored Ambulatory Record (COSTAR V®)[1], employing integrated text processing and decision support features, has been described in other publications[3,4]. The system currently supports multiple clinics serving 35,000 annual encounters and maintains information on 45,000 adult patients.

Hypertension clinic was chosen as a model for the implementation of computerized nursing support because of the defined scope of patient problems, and the more independent role that nursing assumes with these patients. COSTAR records were audited for nursing involvement by a multidisciplinary team. From these reviews, eight nursing care domains were defined, with a total of forty-two problems for nursing concern.

As the functional specifications for the nursing history program evolved, we chose a rule based model for implementation because we desired: 1) incremental development of nursing knowledge in rules which could be tested individually, 2) modularity which would lend itself well to issues of time management and 3) enhanced portability to other COSTAR sites since rules could be documented and installed under other COSTAR directory structures. Eventually, we settled upon a system design with the following elements:

1) MQL based rule shell for maintenance of medical logic modules (MLM)
2) Encounter MLM trigger engine
3) Interactive question manager
4) Working set for nursing history MLM's
5) Working set for nursing intervention MLM's
6) COSTAR V ambulatory medical record

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The interaction of these elements is shown schematically in figure 1. The function and interaction of each of the elements is described in the following paragraphs.

1-Medical Query Language Rule Shell

Medical Query Language (MQL) is a powerful MUMPS® application generator which we use extensively at our sites. MQL compiles a fourth level language into MUMPS routines designed for the structure of our COSTAR data base. To install nursing rules, we developed a rule production shell within MQL. This shell allows the MQL user to develop a production rule in the form of an MQL coding macro. The cross links and documentation features for each rule, sometimes called a Medical Logic Module (MLM), follow the Arden syntax[6] in order to enhance portability.

2-Encounter MLM Trigger Engine

The MLM's we have implemented thus far for management of hypertension are small in number. As the number of problem domains and MLM's increase, efficient use of run time will become critical. Our design therefore, uses a program which executes when the patient arrives in clinic. This program reviews the nursing history MLM list (box 4 in figure 1) for the patient and refreshes the list based upon the triggers set up by the knowledge engineer. An MLM may be triggered for the patient by a problem in the record, features of that day's encounter, or by a preset recurrence scheme. This program organizes the pursuit of the nursing history prior to the nurse interview with the patient.

3-Interactive Question Manager

Once in the examination room, a Nursing Intake Module we have described in a previous paper[4], directs the technician or RN to obtain the basic vital signs. When these are recorded, a specially designed interactive question manager (box 3 figure 1) directs the dialogue. This program keeps track of elapsed time for the nursing history, and informs the nurse of the number of questions and interventions in the current sets. An example of the nursing screen is included in figure 2.

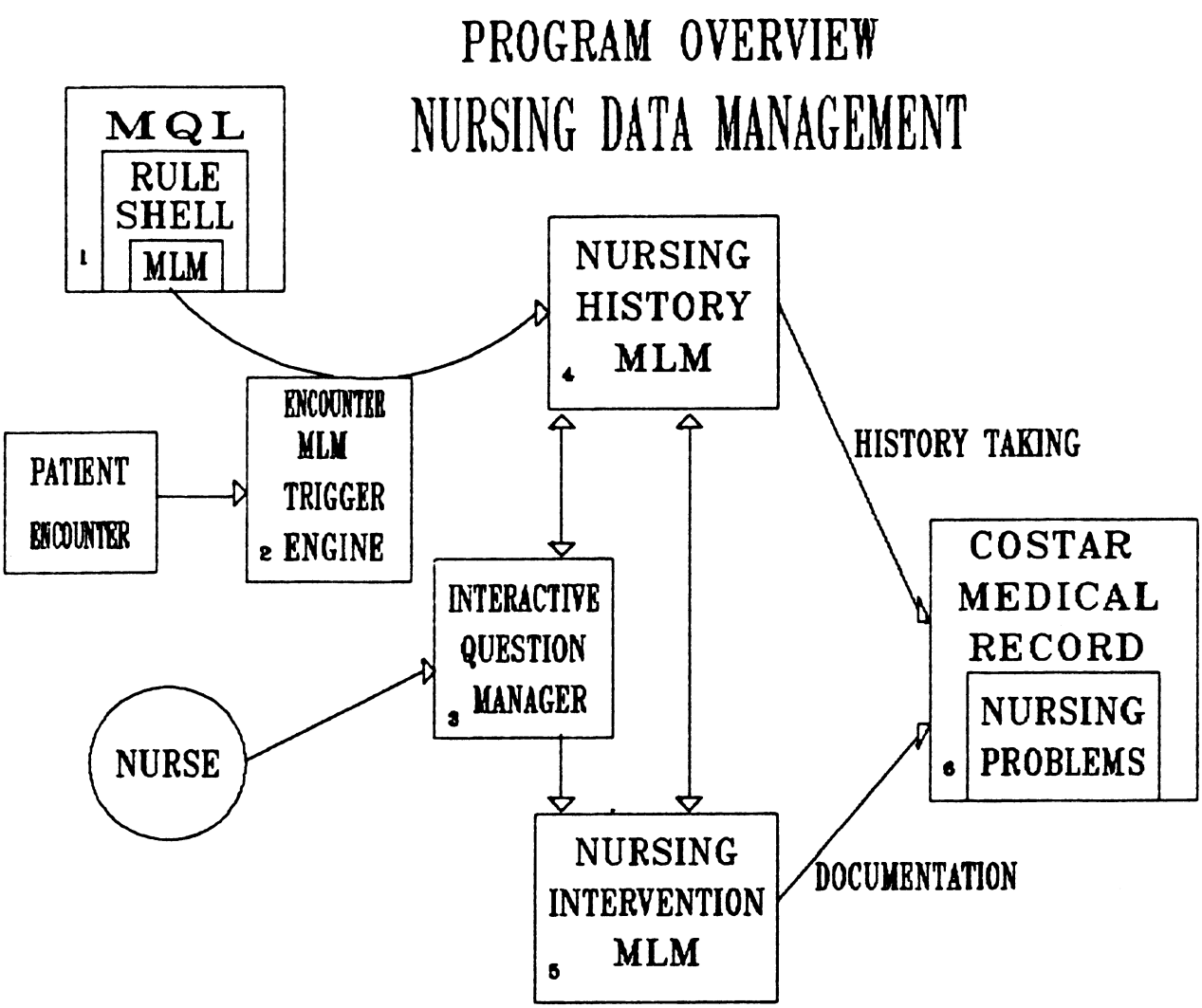

Figure 1

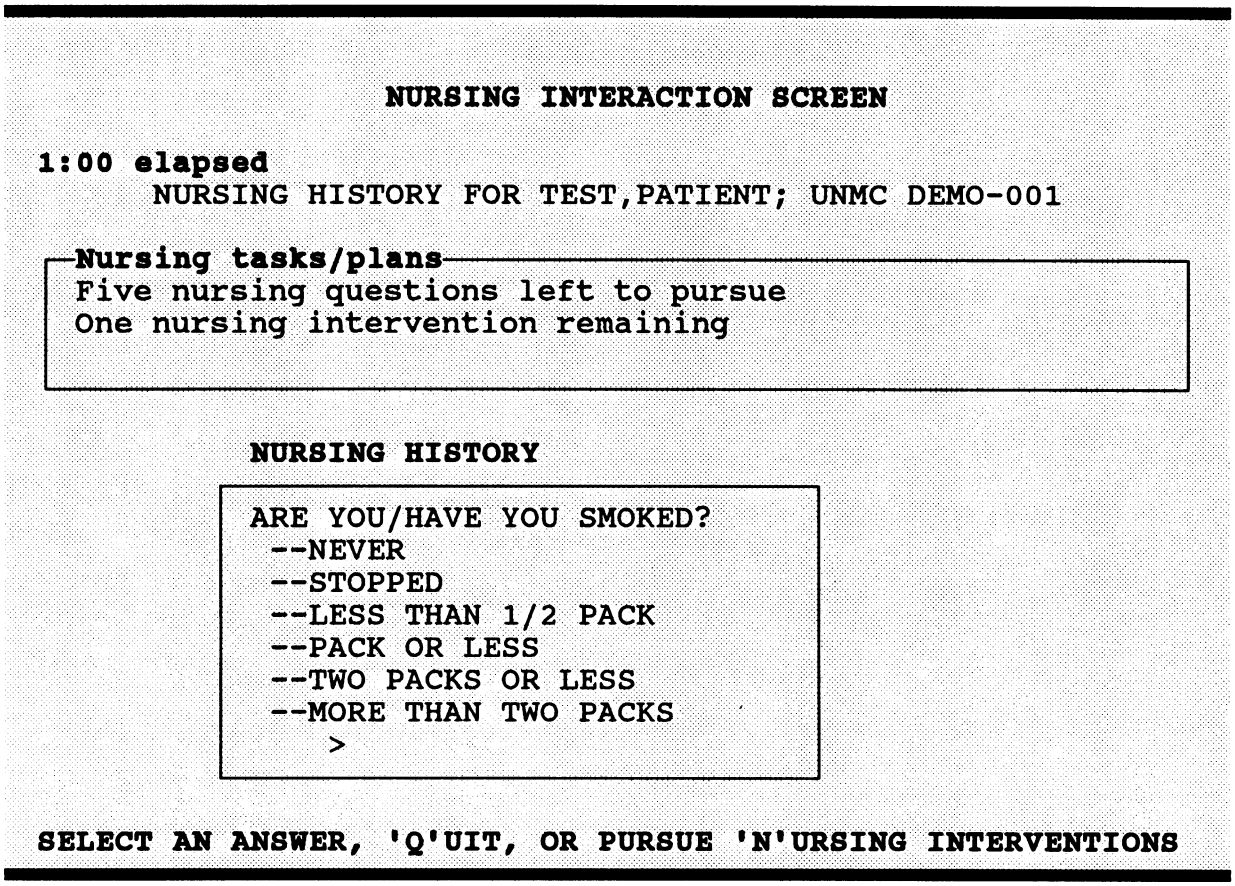

Figure 2

All MLM's in the history set are assigned a priority score at the time of their creation. This priority score determines the sequence of questioning, but the nursing staff member may allocate time to history taking, nursing interventions, or problem list review as they see fit. These features of choice are built into the program in order to allow the module to work with a heterogeneous staff subject to varying time pressures. When the nurse finishes, he/she exits the module and a presentation manager described previously[4] selects MQL display packages for use of the physician.

4-Working Set of Nursing History MLM's

Two lists of MLM's are maintained longitudinally on disk for every patient seen in clinic. This assures eventual follow-up of important nursing plans despite conflicting demands on the nurses' time. The first set are the rules identified for the patient governing the nursing history sequence. A sample nursing history MLM is included in figure 3. These are placed in the working set by the encounter MLM trigger engine, or may be added by other history MLM's at the time of their execution. Nursing history MLM's may record information in the record, create or resolve nursing problems, add other history MLM's or trigger nursing intervention MLM's (see item 5 below). An MLM is not removed from the active list until completed.

5-Working Set of Nursing Intervention MLM's

Nursing interventions are also MLM's which may document patient care, prompt the nurse for educational/instructional tasks, create or resolve nursing problems or inactivate themselves when completed. A sample nursing intervention MLM is included in figure 4. Nursing interventions generally require an RN and so the interactive question manager leaves the decision to pursue these to the staff member doing the intake history.

6-COSTAR Ambulatory Medical Record

Implicit in the description of this program set is a longitudinal, robust, computer record of patient care. Problem oriented COSTAR has been modified slightly at our site to maintain a nursing problem list integrated with the remainder of the record. The historical data accumulated by the nurse is stored directly into COSTAR and used in our reminder systems. Some of the nursing goals are designed specifically to capture information necessary for these decision aids. Nursing education, counselling and advice are documented in the computer record as they are accomplished.

SAMPLE NURSING HISTORY RULE

MAINTENANCE

TITLE: NURSING SMOKING HISTORY
FILENAME: NRS002
CREATOR: CAMPBELL,JAMES RICHARD,MD CREATED: 2/22/91

LIBRARY
PURPOSE: RECORD SMOKING HISTORY; INITIATE NURSING REFERRALS FOR PATIENTS WILLING TO QUIT
KEYWORDS: SMOKING, SMOKING CESSATION

KNOWLEDGE
TYPE: NURSING HISTORY
DATA: SMOKING HISTORY
TRIGGERS: EVOKE ON PROBLEM (HCM), RECURRENCE (ANNUALLY)
LOGIC/ACTION:

***Retrieve smoking history from record, if on file and nonsmoker: remove NRS002 from active questioning: END**
***Ask patient about past and present smoking behavior: store codified results in record**
***If nonsmoker: remove NRS002 from active questioning: END**
***Store nursing problem in record: "PERSONAL HEALTH MANAGEMENT: SMOKING"**
***Ask if patient wants to quit smoking: store codified results in record: END on 'NO'**
***Trigger nursing task rule NRS003**
***Remove rule NRS002 from nursing history list; END**

Figure 3

Implementation Strategy

Members of our Nursing College and clinic staff members have been integral to the development and implementation of this program. After preliminary programming and rule description, a presentation and demonstration of the program was affirmed overwhelmingly by the staff. After three months of experience with the programs, a questionnaire asking for nursing assessment of the system was circulated. A summary of nursing comments pointed to unanimous acceptance of the exam room computer terminals. The small number of staff involved with hypertension clinic were polled regarding their experience with computerized nursing rules. In general, they were positive about the changes and did not feel that it lengthened the intake exam. They expressed some concern about "ownership" of the changes and their part in the process.

Many users at our site have been trained in the use of MQL. The complexity of the logic used in many MLM's has made it difficult for the "average" MQL user to implement these functions. Nonetheless, the familiarity of MQL has allowed staff members to participate in the process of knowledge engineering, improving the speed of this complex installation.

Discussion

Although traditional implementations of knowledge systems have focused upon differential diagnosis, many examples of management programs exist[8]. These systems have often had minor clinical impact because they were tied to a unique programming language, an expensive piece of custom hardware, or required users to reenter information already recorded elsewhere. Additionally, they usually required a separate programming staff to engineer the knowledge developed by expert clinicians. The Regenstrief record and HELP® have been examples of systems that have begun to close the loop, tying computerized clinical information to various types of decision support technology.

The program design that we report herein is the latest in a series of experiments to tie a computerized medical record system directly to a program which employs decision support technology. This design takes a step towards further enhancing the information source (the record) by using the knowledge of a rule system to actually guide the care givers in data base development and maintenance. Given the importance of the nurse in the ambulatory environment and his/her utility in data gathering and decision making, we believe this is a critical experiment. Although an expanding knowledge base will undoubtedly present new problems, our experience thus far is favorable.

Increasing experience points to an ideal medical records system that will organize itself around what is already known about the patient. Intelligent systems will be the standard of record keeping in the near future. The intelligence will be required not only for efficient access to information, but also in comprehensive and robust data gathering. Based upon the central role of ambulatory nursing in

SAMPLE NURSING INTERVENTION RULE

MAINTENANCE

TITLE: NURSING SMOKING INTERVENTION
FILENAME: NRS003
CREATOR: CAMPBELL,JAMES RICHARD,MD CREATED: 2/22/91

LIBRARY
PURPOSE: PROVIDE PRINTED EDUCATIONAL MATERIAL AND INITIATE COMMUNITY REFERRAL FOR PATIENTS WHO WISH TO STOP SMOKING
KEYWORDS: SMOKING, SMOKING CESSATION

KNOWLEDGE
TYPE: NURSING TASK
DATA: NONE
TRIGGERS: NONE
LOGIC/ACTION:

- ***Display message: "Patient has indicated a desire to stop smoking; provide with handout package on smoking cessation and phone number of counsellor"**
- ***Confirm action: record nursing education in record: END if not completed**
- ***Display message: "Notify physician of patient desires to evaluate for possible use of smoking cessation aids"**
- ***Remove NRS003 from nursing intervention list**

Figure 4

information gathering and case management, this program development is an important item in progress towards such a goal.

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